Smart Agricultural Resources Optimization System: The case for sensor-based automatic irrigation management

Abstract

To be finished after discussion of results

Introduction

Small scale agriculture has been found to suffer from several technical inefficiencies (Seyoum, 1998). This is due to several causes ranging from lack of technical knowledge by smallholder farmers, to lack of equipment to improve practices. These technical inefficiencies affect different facets of agricultural production. In particular they have an impact on the quantities of inputs such as water that are utilized in production (Speelman, 2008). Technical inefficiency leads to the wastage of limited and crucial resources needed for agriculture such as water. It has been estimated that small-scale irrigation schemes can have up to 49% inefficiencies attributable to technical limitations (Speelman, 2008). This is of significance given the importance such resources have in contributing to livelihoods and development in farming communities. It is also a pertinent issue given the pressure exerted on such resources by growing populations and climate change. Studies have shown that the productivity of rice systems for instance can be raised by increasing the technical efficiency of smallholder farmers (Idiong, 2007). The pressure on resources and the potential for increasing productivity make a strong case for enhancing technical efficiencies in smallholder agriculture.

Various solutions have been designed to increase the efficiency with which agricultural resources are utilized. Some of these solutions have focused on reducing water released by irrigation systems for instance. Various techniques have been applied to achieve this. Among the methods applied is the use of technology to limit water release. The solution we propose lies along this framework where we use instrumentation and control to optimize how resources are used in agricultural production. This Concept Note uses the example of water as a limited resource whose technical efficiency can be improved through the use of climate-smart technologically based solution. Our solution is designed to meet the needs of smallholder farmers in developing countries, whose lack of technical knowledge leads to inefficiencies. This is particularly around small-scale irrigation where the amount of water used could be significantly reduced if decisions on when to irrigate were made based on technical knowledge. Since it is not practical to equip farmers with all the technical knowledge needed to make these decisions, our solution relies on technology to assist a farmer

improve their technical efficiency. It uses micro-controllers, which are small computer processors that can receive data and perform logical computations. It also uses sensors that can detect various conditions in the immediate environment to determine if irrigation is needed. The solution has been designed around the needs of smallholder farmers in developing countries. This concept paper describes a climate-smart technological solution designed to improve technical efficiencies among smallholder farmers.

The objective of this solution is to increase the technical efficiency of agricultural resource utilization. It aims to reduce the water wasted in small-scale irrigation, while helping monitor the health of the soil to provide information for decision making to various stakeholders.

Methodology

The solution is built around a field-deployable kit that monitors the weather, soil moisture and other environmental parameters to determine when irrigation should be done and how much water needs to be released. All this is based on data collected by the kit from the environment where it is located. The kit has sensors that measure a variety of environmental conditions and relay the data to an onboard micro-controller. The controller evaluates this data to determine if it is necessary to irrigate the land, while also monitoring other aspects of soil health. In this way the kit is able to regulate the amount of water used in crop production to a very high degree of efficiency, since it can be programmed with all the technical knowledge necessary to make informed decisions. The kit can be configured to automatically open irrigation systems when it detects crops need watering, thus allowing the mechanization of task. This not only allows higher levels of efficiency to be achieved, but it also has the dual advantage of freeing the farmer from the task of watering plants on a continual basis. This means more time for the farmer to engage in other activities but it also means plants get water whenever they need it with no delays or over irrigation due to human error. The kit loges the amount of water dispersed during each irrigation cycle and this information is made available to the farmer through their mobile handset. By connecting to a back-end system where the soil health data is uploaded, the kit will send back data that can be used to inform land management decisions. This information will be useful for detecting land degradation before soil fertility is compromised, allowing appropriate interventions to be identified and targeted. The solution will provide a service that farmers can connect to trough their mobile phones to get this land management information from the back-end system. In this way farmers will be able to increase the efficiency in which they use other agricultural inputs by basing their land management decisions on technical data. The combination of the kit and the back-end is what we have named the System for Agricultural Resource Optimization (SARO).

Expected outcomes

We expect this solution will increase the technical efficiencies of small-scale irrigation and will be particularly useful in places where water efficiency is a strategic issue. It will also enhance land management by providing farmers with strategic climate-smart information on the health of their soils. The combined effect of this is expected to be an increase in productivity and more strategic resource management.

Beneficiaries

This solution is primarily targeted at small holder farmers whose technical knowledge on soil and water issues is not high. The solution is meant to bridge this knowledge divide thus allowing the farmers to increase their technical efficiencies. By basing resource use decisions on actual climate-smart data and knowledge, the kit will remove much of the guesswork and risk exposure to vagaries of rainfall variability involved in small-scale irrigation allowing with better adaptation to climate change. The land management data logged to the back-end of the system will allow farmers to query and receive information about the state of the soil and water resources from the convenience of their mobile handsets. The system will also provide other stakeholders with a platform to monitor land health and resource use information thus mitigating any unintended environmental consequences. This will provide policy makers with information from field scale to landscape scale allowing better decision making across the board.

Preliminary Cost Benefit Assessments

Below is a list of other supplementary benefits being monitored at two field sites in Kenya and Tanzania.

Attribute per ha	Unit (amount)	Cost	Comment on Benefit
Labor savings *(Alternative livelihood options resulting from labor savings)*	Man hours/annum	88,536 KES; about 885 USD per annum.	60% labor savings; based on about 280 days of full time labor; SAROS saves the farmer about 168 days; based on minimum wage fee earnings of 527 KES/day would amount to 88,536 KES; about 885 USD per annum.
Water savings	Liters/annum (over 4 seasons)	2,040,000 litres saved from SAROS; at a cost of about 55 Kenya Shillings=1.12 M USD	This has cost implications in that farmers spend less and more water could be available for other uses

			(domestic and other food production needs)
Benefit of farming in water scarce area (Value of out of season crop)	$/annum		
Crop yield differences (Vs not irrigated)	Ton/Acre		

References

Seyoum, E. T., Battese, G. E., & Fleming, E. M. (1998). Technical efficiency and productivity of maize producers in eastern Ethiopia: a study of farmers within and outside the Sasakawa-Global 2000 project. *Agricultural economics*, *19*(3), 341-348.

Speelman, S., D'Haese, M., Buysse, J., & D'Haese, L. (2008). A measure for the efficiency of water use and its determinants, a case study of small-scale irrigation schemes in North-West Province, South Africa. *Agricultural systems*, *98*(1), 31-39.

Idiong, I. C. (2007). Estimation of farm level technical efficiency in smallscale swamp rice production in cross river state of Nigeria: a stochastic frontier approach. *World Journal of Agricultural Sciences*, *3*(5), 653-658.